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THE RAPID MINERALIZATION OF ORGANIC REMAINS IN FLORIDA, AND ITS BEARING ON SUPPOSED PLEISTOCENE RECORDS [1]

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Toward the latter 1800's, there were several finds of heavily mineralized human remains in Florida. At a locality on Sarasota Bay, human bones were found imbedded in a soft ferruginous rock. Further excavations in the general area revealed a skeleton in ferruginous sandstone; the bone substance had been entirely replaced by limonite (Heilprin, 1887; Leidy, 1889). In other parts of the state, human skulls were discovered in masses of breccia. At first, great age was attributed to the various finds, mostly on the basis of the degree of mineralization. However, somatologically the bones were those of American Indians; and in some cases they were associated with artifacts, such as pottery, which elsewhere in the state appeared to be of no great age. Furthermore, the most impressively mineralized skeleton, that from Sarasota Bay, was accompanied by the remains of modern animals only. Dall (1887) reasonably concluded that, in parts of Florida, mineralization must proceed at a very rapid rate, and that one is not justified in assigning an early dating to remains from this state simply because they are completely petrified. Hrdlicka (1907) reached a similar decision after study of the geological and archeological evidence. Recently developed techniques of archeological dating have amply borne out the conclusions of Dall and Hrdlicka, in so far as they relate to petrifaction as a measure of antiquity in Florida. Thus it has become evident, at least to archeologists, that in Florida

[1] A contribution from the *Research Division, Ross Allen Reptile Institute.*

mineralization is not necessarily an indication of Pleistocene or even "early Recent" age (see Goggin, 1952; Rouse, 1951; and Willey, 1949). Unfortunately, this dictum has been overlooked by some zoologists, who continue to assign at least a Pleistocene dating to all fossilized animal remains from this state.

I wish to emphasize that, under conditions frequently met with in Florida, petrifaction is a matter of centuries, not millennia; to report that, under ideal conditions, it is a mere matter of decades; and to discuss certain remains which have been ascribed, perhaps erroneously, to the Pleistocene.

At this point it seems desirable to explain what is mean by "Pleistocene." This epoch is differentiated from the preceding one by glaciations and the establishment of climatic zones, but to draw a line between Pleistocene and Recent is pure arbitration (Hibbard, 1949). The line has been drawn in a variety of ways, and by many authors, but never in really satisfactory fashion (Ray, 1949). Most zoologists, pronouncing various remains from Florida to be of "Pleistocene" rather than of "Recent" age, have given no indication of the way they distinguish these time periods. Although from a geological standpoint the Pleistocene has not ended, it is zoologically useful to separate the last part of post-Pliocene times, characterized by a modern fauna, from the preceding part when elephants, giant bison, etc. also flourished. Flint (1947) and Hibbard (*op. cit.*) have recommended that the term "recent" (with a lower-case "r") be used in an informal and local sense to designate the time period characterized by the modern fauna. Their recommendation is followed herein; "Pleistocene" and "recent" are thus distinguished faunistically. Probably the majority of zoologists have had some such distinction in mind when assigning remains to the Florida Pleistocene without additional comment.

With this preamble we may turn to the subject of mineralization and its bearing on supposed Pleistocene records. Three instances of very rapid mineralization may be cited. At the Reptile Institute a crocodile was kept in an enclosure built along a natural stream, a tributary of Silver Springs run in Marion County, Florida. On one occasion a quantity of redfish heads were purchased as food for the reptile. Thrown into the pen, many of the heads sank into the muck of the stream bottom, and the crocodile did not eat them. About 15 years thereafter, muck was dug from the pen and several redfish skulls recovered. They were jet black in color, extremely

hard, and somewhat heavier than ordinary redfish skulls of comparable size. After months of drying, they lost a little weight, and parts of them became lighter in color. Nevertheless, they are still remarkably heavy and indurated, with the smooth surface and dark coloration typical of fossil material from many parts of Florida. They seem to be more heavily mineralized than some of the mammoth and mastodon bones found at the Bon Terra Farm site (Neill, 1953). They are far more heavily mineralized than most of the remains from the lower, preceramic levels of Indian shell middens in Florida (Neill, Gut, and Brodkorb, 1956).

A second instance of rapid petrifaction was observed by Mr. James M. Boyles, of the Department of Biology, University of Alabama, and myself, at Lake Jessup, Seminole County, Florida. At the edge of the lake we encountered three stumps of the cabbage palm (*Sabal palmetto*). The trees had been sawed off, neatly and squarely, obviously with a metal saw. The stumps sprang from the same ground level as the many living cabbage palms about them, and could scarcely have been much older; yet they were so heavily mineralized that they could not be scored, much less cut, with a knife. When rapped with a metal knife butt, they rang like stone. Clearly, petrifaction had taken place within a few decades. Certain rural residents later told me that they occasionally found mineralized stumps about lake margins, and prized fragments of these stumps as whetstones.

A third example of rapid mineralization was brought to my attention by Mr. C. E. Burkhardt, of High Springs, Florida. On the surface of an Indian midden he picked up two cut sections of mammal femur. Each is obviously the bone from a "round steak," and had been cut with a saw, the marks of which are still plain. The bones, probably left by modern picnickers, are more heavily mineralized than fossils from some Pleistocene sites. Presumably the midden soil was unusually rich in minerals.

It is not surprising to find evidence of extremely rapid petrifaction in Florida, especially in the case of remains exposed to water. Many bones (and also palm stumps) exhibit a finely porous structure through which water will pass. Dissolved solids are thus very apt to be deposited within organic remains; and of course, many Florida waters bear extraordinarily heavy loads of salts and other minerals (Ferguson *et. al.*, 1947; Odum, 1953). Whatever the chemistry of the matter, it is evident that organic remains may become

thoroughly fossilized after relatively brief exposure to certain mineral-laden waters of Florida.

The three aforesaid instances of rapid petrifaction may be unusual. Nevertheless, it is possible to demonstrate that animal remains, postdating the Pleistocene by thousands of years, have very frequently become mineralized to an extreme degree. The prehistoric Indians of Florida often littered their encampments with bones—food remains and discarded implements. In many cases, material from archeological sites may be dated with considerable precision (Heizer, 1953). Bones no more than three or four thousand years old, collected from Indian sites along streams, are often more heavily mineralized than the remains of extinct Pleistocene animals. Bone implements which fell into streams often seem to be completely mineralized and stone-like in consistency. In many Florida waters, a few millennia, if not a few centuries, commonly suffice to bring a bone to its maximum possible degree of petrifaction. As a matter of fact, the bone litter of Indian encampments need not be submerged in order to mineralize within a few millennia. The situation at South Indian Field, Brevard County, is quite typical of many archeological sites in Florida. Animal remains from two excavations at this locality were studied by Houck (1951). Bones from the lower levels of the excavations were "often dark, heavy, encrusted with calcareous material, and themselves mineralized" (*ibid.*, p. 51). The lower levels date from what archeologists now call Orange, Late times, as shown by the presence of a characteristic pottery, Orange Incised (Rouse, *op. cit.*). This ware made its appearance about 450 B. C., and its use was discontinued in eastern Florida around 150 B. C. (Goggin, *op. cit.*). In other words, at this site the remains of numerous animals had become heavily mineralized in something less than 2500 years.

Conversely, Pleistocene remains are sometimes but lightly mineralized. Bones of the American mastodon, Florida saber-tooth, Florida short-faced bear, etc. are of Pleistocene age by definition. Frequently they are very lightly mineralized, as examination of any extensive paleontological collection will show. Of course, one sometimes encounters the statement that the Pleistocene animals may have survived longer in Florida than elsewhere (*e. g.*, Gidley and Loomis, 1926; Wormington, 1949, p. 133). However, this guess stemmed from efforts to prove a contemporaneity of man

and extinct animals in Florida, and to explain away the occurrence of relatively modern Indian artifacts (such as pottery) in a supposedly undisturbed Pleistocene stratum (*cf.* Sellards, 1916, pp. 123, 159-160 with Rouse, *op. cit.*, pp. 162-165, 235-236). The fortuitous nature of the association has since been demonstrated (Rouse, *op. cit.*) to the satisfaction of most Florida archeologists, and there is no reason to suspect that the Pleistocene fauna persisted in this state longer than in other parts of North America. In fact, the actual evidence points mostly in the other direction. Along the water courses of eastern North America, including Florida, are found great heaps of mollusk shell, the refuse middens of Indians. The deeper levels of the larger middens date from what archeologists call preceramic Archaic times. Radiocarbon dates for a number of localities in the Southeast reveal that the preceramic Archaic began more than 7000 years ago. Oldest radiocarbon dates for the Southeastern Archaic are 7374 plus or minus 500 years (Johnson, ed., 1951), and 7150 plus or minus 500 years (Kneberg and Lewis, no date). Archaic and later sites often are rich in the remains of animals, and these are always of the modern species; numerous site reports attest to this fact. Bones of the extinct Pleistocene animals, in Florida at least, clearly are older than the Archaic middens, older than the Indian artifacts and debris to which reference has been made.[2]

Thus it is possible to state with assurance that the degree of fossilization is not necessarily a criterion of age; it varies with the amount of dissolved minerals to which a given bone has been exposed, and probably with the bone's structural capacity to take up minerals. This conclusion is fairly obvious; nevertheless, it has been widely ignored. The foregoing discussion has thus appeared necessary. Modern streams, which often cut through recent and Pleistocene deposits in Florida, are apt to bring together remains from both periods, for debris tends to collect in spots along stream beds, either in pockets or in areas where the current is slowed. It is not unusual to find in one spot the bones of both extinct and modern animals, Indian artifacts, the refuse of early 19th Century

[2] At several localities in the western United States, human remains and artifacts have been found in definite association with the bones of extinct animals. Where dated by radiocarbon, these paleo-Indian sites are older than the Eastern Archaic. The circumstance has little bearing on the present argument, which is concerned with the establishment of a modern fauna in Florida by Archaic times.

inhabitants, and the debris of present-day picnickers (Neill, 1952). A mastodon bone washed into the stream by last week's freshet may conceivably be less mineralized than, say, an opossum bone cast into the water by an Indian a few centuries ago. The fossilized remains of modern species, recovered from Florida stream beds, cannot safely be assigned to the Pleistocene even though they may accompany similarly fossilized remains of extinct species.

Animal remains may be deemed of Pleistocene age if they are of the extinct species whose presence characterizes this epoch; and the remains of living species may be assigned to the Pleistocene if they were found *in situ* within an undisturbed formation of this time period. In some parts of the world, heavy mineralization may also imply a Pleistocene or earlier dating, although in Florida petrifaction is not a criterion of age. Probably no author has expressly stated that he assigns certain remains to the Pleistocene of Florida solely on the basis of their mineralization. Nevertheless, as authors have commonly made such assignments without corroborative faunistic or stratigraphic data, there must often have been a tacit assumption that mineralization justified a Pleistocene rather than a recent dating. Certain "Pleistocene" records are thus questionable, and must be reconsidered.

For example, the modern beaver (*Castor canadensis*) has been reported from the Pleistocene of Florida on the basis of mineralized remains from Ichtucknee Spring run, Columbia County (Simpson, 1930). The remains were associated with those of elephants, mastodon, etc., all presumably of Pleistocene age, as well as with those of the modern opossum, raccoon, otter, and deer. Sherds of Indian pottery are also very common in the bed of Ichtucknee Spring run, along with the mastodon and other remains. No authority would now argue for a contemporaneity of the Pleistocene remains and the Indian pottery; Florida sites far antedating pottery yield only the remains of modern species (Neill, Gut, and Brodkorb, *op. cit.*). The association in a stream bed of pottery and the bones of extinct animals is no more remarkable than the presence of pop bottles in the same place. A question therefore arises: Are the beaver remains contemporaneous with those of the elephants, or could they be the refuse of later Indian encampments? The degree of mineralization will not aid in solving this problem; a survey of the literature, and of collections, is suggestive, however. In a talk before the Florida Anthropological Society, Mr. H. James Gut

summarized what was known of the beaver in prehistoric Florida (Gut, 1952). The only finds tentatively attributed to the Pleistocene were from stream or lake bed deposits (Ichtucknee Spring, Lake Monroe, and the St. Johns River). The antiquity of these finds is therefore open to question; and Gut quite properly listed them as "possibly Pleistocene." On the other hand, remains of the modern beaver have been recovered from at least four Indian sites in peninsular Florida (Neill, Gut, and Brodkorb, *op. cit.*), in a context dating no earlier than about 1550 B.C. Apparently the species was absent from the peninsula during most of the preceramic Archaic, making its appearance as this archeological period was drawing to a close. Of course, the modern beaver may some day turn up in the Florida Pleistocene. However, one can interpret a situation only in the light of present knowledge, which suggests that *C. canadensis* did not enter the state until the recent period.

Simpson (*op. cit.*) reported the muskrat (*Ondatra zibethica*) from the Pleistocene of Florida on the basis of specimens from Ichtucknee Spring run. Remains of the round-tailed water rat (*Neofiber alleni*) were also found in the Ichtucknee and assigned to the Pleistocene. Simpson (*op. cit.*), Lawrence (1942) and Schwartz (1953) all concluded, therefore, that the two species occurred together in Florida during the Pleistocene, although today the two are mutually exclusive geographically. The present distribution is not surprising. Being similar "in habitat and food requirements and general conditions for life" (Schwartz, *op. cit.*, p. 22), they are much more apt to be vicariants than competitors, in accordance with a general ecological rule. The Ichtucknee muskrats may be of Pleistocene age, having been described as a subspecies differing slightly from all modern ones in certain skull characters (Lawrence, *op. cit.*). However, in this connection it would be interesting to know the subspecific identity of the muskrat reported from an Indian site in North Florida and dating from around 500 B.C. (Neill and Bullen, 1955). At any rate, it does not follow that the water rats from Ichtucknee are of the same age as the muskrats. *Neofiber* bones are common at Indian sites, and those from Ichtucknee might be contemporaneous with the pottery found therein. Furthermore, granting that both water rat and muskrat date from the Pleistocene, there is yet no certainty that they are of equal age. During a peak of glaciation, cold weather may have forced the water rat into South Florida and enabled the muskrat to enter North Florida;

with the returning warmth of an interglacial or postglacial period, the water rat may then have advanced northward as the muskrat retreated. Simpson (*op. cit.*, pp. 1-2) admitted, "The association of artifacts and extinct animals [at Ichtucknee] is not important, in view of the type of deposit;" but obviously the association of *Neofiber* and *Ondatra* in the same deposit is equally unimportant from a temporal standpoint. Judging from the literature, remains of these two rodents have not been found together in Florida outside a stream bed. Cooke (1926) did mention muskrat at the Melbourne site but apparently he had *Neofiber* in mind, for subsequent tabulations of the Melbourne specimens included only the latter. Lawrence (*q. v.*) cited several authors who had found only *Neofiber* at various rich Pleistocene localities in Florida. One receives the impression that these two species were vicariants in the Pleistocene, just as at present. Here again, future collecting may negate my interpretation; but at least one may advocate extreme caution in accepting numerous "Pleistocene" records based solely on mineralized remains from Florida stream beds.

Brattstrom (1953) listed many supposed Late Pleistocene records of amphibians and reptiles from Florida. Apparently he did not investigate the sites involved, but relied on Cooke's (1945) summary of Florida geology. Later papers were not examined. Brattstrom's records included vertebrae of the large, burrowing salamander, *Amphiuma means*, from Stratum No. Three at Vero Beach, St. Lucie County; from Seminole, Pinellas County; and from Wakulla Springs, Wakulla County. (The last locality was erroneously placed in Leon County by Brattstrom.) All these records of *Amphiuma* are open to question. The Vero Beach locality may be considered briefly. There in 1915, and again in 1916, human bones and artifacts were found in association with the remains of extinct Pleistocene animals. At that time, in the absence of modern excavating techniques and definitive archeological knowledge, it was contended that the human remains were contemporaneous with those of the extinct beasts. Viewed in the dispassionate light of modern knowledge and techniques, the situation is much clearer (Rouse, *op. cit.*). The Vero Beach site was occupied by Archaic Indians in the early part of the recent period, when the climate was relatively dry and sea level lower than at present. The Indians deposited a good bit of refuse, including the bones of modern animals as well as their own bones. They also dug a burial pit into

the underlying Melbourne (Late Pleistocene) formation, thus commingling Pleistocene and recent material. Later Indians occupied the site during what archeologists call the Malabar I′ period, which began not long before the Christian Era. They dug a large, deep well at the site, and in so doing commingled their own refuse with that of the earlier inhabitants and with animal remains originally from the underlying Melbourne formation. Sea level gradually rose, and with it the water table; the site eventually became a marsh, and the Indians abandoned it. It was a marsh at the beginning of the 20th Century, when canals were dug to drain it; and many of the "Pleistocene" finds were taken from spoil banks of the canals. Much of the material was collected by enthusiastic but untrained local residents. In view of the extreme disturbance at the Vero Beach site, by prehistoric and modern man, one could not assign the *Amphiuma* remains to the Pleistocene except on the dubious basis of their mineralization (which in any event is not impressive). *Amphiuma* is an inhabitant of bogs and marshs; and I suspect that Brattstrom's "Pleistocene" remains are actually those of specimens dwelling in the marsh that formed within the Christian Era. Furthermore, *Amphiuma* is strikingly modified, both in anatomy and physiology, for subterranean life; specimens have been dug from beneath 15 feet or more of mucky deposits. No doubt today, near Vero Beach, many an *Amphiuma* leaves its remains somewhere along the contact plane between the Melbourne formation and the underlying Anastasia coquina, there to mineralize in a few centuries!

The Wakulla Springs site merits only brief discussion, in view of the previous comments on mineralization in Florida waters. Wakulla is rich in minerals which color bones a characteristic bluish shade. Mr. V. J. Allen, of Dunnellon, Florida, recovered from the spring bed many Indian artifacts of bone. Some of these, now in my possession, are completely petrified, having the consistency of stone. It is probable that *Amphiuma* remains, no older than these artifacts, would be comparably petrified. The heavily mineralized bone objects have included splinter awls, long and short bone points, and decorated pins of several kinds; these are more or less characteristic of Archaic times, especially the latter Archaic. It is fairly safe to conclude that a mineralized bone from Wakulla need not be more than 2500 years old, if that. A Pleistocene dating

cannot be accepted for any animal remains from this spring, except those of extinct species which are Pleistocene by definition.

The material labeled "Seminole" came originally from the bed and flood plain of a stream, Joe's Creek, now in St. Petersburg. On two occasions, dredging of the creek uncovered animal remains, including both extinct and modern species. The abundance of extinct animals at Seminole implies that most of the remains truly date from the Pleistocene (Simpson, 1929). However, I would hesitate to accept the *Amphiuma* record as being of Pleistocene age, for several reasons. First, Seminole is another stream bed locality; second, it has been disturbed by dredging; third, there is some evidence that the deposits have been reworked by nature. Opportunities for a commingling of recent and Pleistocene material have been too numerous to permit unquestioning acceptance of a Pleistocene dating in the case of a paludicole like *Amphiuma.*

Seminole, Wakulla, and Stratum Three at Vero Beach have been discussed with special reference to *Amphiuma;* but obviously, most of the remarks are applicable to the remains of other modern species from these localities. As noted, the general run of material from Seminole is apt to be of Pleistocene age; but, since remains of two periods have been mixed there, one cannot accept unreservedly the Pleistocene dating (Brattstrom, *op. cit.*) for the vertebrae of several modern amphibian and reptile species collected along the creek bed. Some of these species are characteristic of mucky streams; and in fact, the entire herpetofaunal assemblage reported by Brattstrom from Seminole would be expected in the general vicinity of the creek valley today. Of course, this circumstance does not prove anything; but the muck of the stream bed should yield the remains of at least a few animals that died in recent times.

A vast amount of mineralized "Pleistocene" material, reported from stream beds or other water-laid deposits of Florida, must be viewed with suspicion. Various authors have, without comment, ascribed a Pleistocene dating to the remains of modern species collected from Crystal River, Wakulla, Ichtucknee, the St. Johns River, numerous canals, Sarasota Bay, etc. It hardly seems worthwhile to publish additional records of this nature.

And as for Stratum Three at Vero Beach, almost all of the mammal remains therefrom were of modern species, according to the original excavator; the exceptions included a few teeth which, being broken, clearly indicated some disturbance at the site (Sell-

ards, (*op. cit.*, pp. 158-159). Rouse's (*op. cit.*) explanation of this circumstance has been accepted by Deevey (1950), and by archeologists who are specialists in the interpretation of a stratigraphic profile. In other words, remains from Stratum Three are mostly of recent age, and just a few bones, intrusive from Stratum Two, date from the Pleistocene. The degree of mineralization will not aid in segregating the older specimens. This means that most of the specimens from Stratum Three, assigned by various authors to the Pleistocene, are probably of recent age. Included in this category are plants, fishes, insects, frogs, salamanders, turtles, the American alligator, lizards, snakes, birds, and mammals. All but one of the plant species, and some of the animals, apparently were found in the upper part of Stratum Three; *i. e.*, in the muck bed that formed after the site had been abandoned by Indians of the Malabar I′ period. These remains should date from well within the Christian Era. Fortunately, some of the species involved have been collected elsewhere from actual Pleistocene situations, and need not be excluded from the Florida list for that epoch.

Workers in many fields are indebted to paleontologists, who go about the difficult task of identifying fragmentary remains. Few problems are more interesting, or of more widespread concern, than the faunal turn-over marking the zoological end of the Pleistocene. In general, this problem and allied ones are most apt to be solved by on-the-spot investigators who can interpret a given site in terms of the latest geological, paleontological, ecological, and sometimes archeological advances.

Literature Cited

BRATTSTROM, B. H.

1953. Records of Pleistocene Reptiles and Amphibians from Florida. *Quart. Jour. Fla. Acad. Sci.*, 16 (4): 243-248.

COOKE, C. W.

1926. Fossil man and Pleistocene vertebrates in Florida. *Amer. Jour. Sci.*, ser. 5, 12: 441-452.

1945. Geology of Florida. *Fla. Geol. Surv., Geol. Bull.*, 29: 1-339.

DALL, W. H.

1887. Notes on the geology of Florida. *Amer. Jour. Sci.*, ser. 2, 34: 161-170.

DEEVEY, E. S., Jr.

1950. Hydroids from Louisiana and Texas, with remarks on the Pleistocene biogeography of the western Gulf of Mexico. *Ecol.*, 31 (3):334-367.

FERGUSON, G. E., C. W. LINGHAM, S. K. LOVE, and R. O. VERNON
1947. Springs of Florida. *Fla. Geol. Surv., Geol. Bull.*, 31: i-xii, 1-196.

FLINT, R. F.
1947. *Glacial Geology and the Pleistocene Epoch.* New York.

GIDLEY, J. W., and F. B. LOOMIS
1926. Fossil man in Florida. *Amer. Jour. Sci.*, 12: 254-264.

GOGGIN, J. M.
1952. Space and time perspective in Northern St. Johns archeology, Florida. *Yale Univ. Pubs. Anthr.*, No. 47: 1-147, 12 pls.

GUT, H. J.
1952. Notes on the beaver in Florida. MS of talk, 4th annual meeting, Fla. Anthropological Society, Winter Park, Fla. Pp. 1-4.

HEILPRIN, A.
1887. Explorations on the west coast of Florida and in the Okeechobee wilderness, with special reference to the geology and zoology of the Floridian peninsula. *Trans. Wagner Free Inst. Sci.*, 1: 1-134, 19 pls.

HEIZER, R. F.
1953. Long-range dating in anthropology. *In* A. L. Kroeber, ed., *Anthropology Today: an Encyclopedic Inventory.* Chicago.

HIBBARD, C. W.
1949. Pleistocene research. 4. Pleistocene vertebrate paleontology in North America. *Geol. Soc. Amer., Bull.*, 60: 1417-1428.

HOUCK, M. VAN W.
1951. Animal remains from South Indian Field. Appendix to V. M. Ferguson, Chronology at South Indian Field, Florida; *Yale Univ. Pubs. Anthr.*, No. 45: 51-60.

HRDLICKA, A.
1907. Skeletal remains suggesting or attributed to early man in North America. *Bur. Amer. Ethnol., Bull.*, 33.

JOHNSON, F. (editor)
1951. Radiocarbon dating. *Amer. Antiquity*, 17 (1, part 2): 1-65.

KNEBERG, M., and T. M. N. LEWIS
No date. *The Archaic in Western Tennessee.* Mimeographed, 16 pp.

LAWRENCE, B.
1942. The muskrat in Florida. *Proc. New England Zool. Club*, 19: 17-20.

LEIDY, J.
1889. Notice of some fossil human bones. *Trans. Wagner Free Inst. Sci.*, 2: 9-12.

NEILL, W. T.

1952. Unusual rattles from Silver Springs, Florida. *The Fla. Anthropologist,* 5 (3-4): 33-34.

1953. Notes on the supposed association of artifacts and extinct vertebrates in Flagler County, Florida. *Amer. Antiquity,* 19 (2): 170-171.

NEILL, W. T., and R. P. BULLEN

1955. Muskrat remains from a prehistoric Indian site in Jackson County, Florida. *Jour. Mammalogy,* 36 (1): 138.

NEILL, W. T., H. J. GUT, and P. BRODKORB

1956. Animal remains from four preceramic sites in Florida. *Amer. Antiquity,* 21 (4): 383-395.

ODUM, H. T.

1953. Factors controlling marine invasion into Florida fresh waters. *Bull. Marine Sci. Gulf and Caribbean,* 3 (2): 134-156.

RAY, L. L.

1949. Pleistocene research. 9. Problems of Pleistocene stratigraphy. *Bull. Geol. Soc. Amer.,* 60: 1463-1474.

ROUSE, I.

1951. A survey of Indian River archeology, Florida. *Yale Univ. Pubs. Anthr.,* No. 44: 1-292, 8 pls.

SCHWARTZ, A.

1953. A systematic study of the water rat (*Neofiber alleni*). *Occ. Pap. Mus. Zool. Univ. Mich.,* No. 547: 1-28, 3 pls.

SELLARDS, E. H.

1916. Human remains and associated fossils from the Pleistocene of Florida. *Fla. State Geol. Surv., Ann. Rept.,* 8: 121-160, pls. 15-31, figs. 1-15.

SIMPSON, G. G.

1929. Pleistocene mammalian fauna of the Seminole Field, Pinellas County, Florida. *Bull. Amer. Mus. Nat. Hist.,* 56 (8): 561-599.

1930. Additions to the Pleistocene of Florida. *Amer. Mus. Nov.,* No. 406: 1-14, 7 figs.

WILLEY, G. R.

1949. Archeology of the Florida Gulf Coast. *Smithsonian Misc. Colls.,* 113: i-xxiii, 1-599, 60 pls.

WORMINGTON, H. M.

1949. Ancient man in North America. 3rd ed. *Denver Mus. Nat. Hist., Pop. Ser.* No. 4: 1-184.